Annex VII

The effect of human disturbance, related to mussel production and in combination activities, on the abundance and distribution of waterbirds

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Summary

A range of human activities potentially cause disturbance. Coincidence (in time) of disturbance caused by activities associated with mussel production and the potential time that bird populations can use the habitat in the SPA is on average 3-6% for waders and up to 12% for a number of other species. These estimates are gross overestimates as they assume that any disturbance event and its effect persists for the duration of a tidal period and applies throughout the site.

Ecological effects of disturbance

Independently of any habitat changes that may or may not occur due to mussel production in Castlemaine, the activity associated with the fishery and production of mussels has the potential to limit how birds can use this habitat. Disturbance can alter the spatial and temporal distribution of birds at the site, reduce the foraging time available, reduce food intake and increase energy expenditure by birds. The spatial and temporal overlap (coincidence) between normal bird use of the site and activities associated with mussel production is likely to be critical in determining the effect of disturbance.

Types of disturbance

The fishery and production management plan for mussels in Castlemaine Harbour presents information relevant to estimation of disturbance. Fishing for seed is proposed for 2 neap tide periods in late August and during September. The seed will be re-laid inter-tidally during this time. During June-August the previous years seed is dredged from the inter-tidal and re-laid sub-tidlaly. During winter a low level of small vessel activity and inspection of the seed occurs on the inter-tidal area at mid to low tide. During winter larger vessels are also harvesting mussels in the sub-tidal ongrowing area.

Other human activities acting in combination may lead to cumulative disturbance effects. In Castlemaine recorded categories of disturbance include

- low frequency activity of large vessels
- higher frequency activity of small vessels
- frequent walking on the intertidal area to inspect mussels
- vehicle activity on the shore associated with access to fishing vessels and the landing of mussels
- vessel and foot traffic associated with oyster production
- vessel activity and walking on the intertidal area associated with picking of periwinkles
- recreational use of quad bikes and other vehicles at Inch beach and dunes
- low frequency disturbance by vessels and people associated with scientific monitoring at the site

Estimating disturbance

Disturbance can be quantified by estimating the overlap in time and space between mussel production related activity and normal use of the habitat by each bird species. If a large percentage of the time available for feeding and roosting at the site is disturbed by this activity the impact on bird populations could be significant. The data currently available to estimate disturbance effects are limited. Data on vessel and foot traffic is not quantitative and is based only on what is described in the mussel production management plan. Spatial overlap between birds and human activity at low tide or vessels at high tide cannot be estimated quantitatively at present. New information on the spatial distribution of flocks of waterbirds was obtained in 2010 and the effects of individual disturbance events were quantified. It is difficult to estimate the ecological relevance of these disturbance events. Ideally all disturbance events would be recorded, their effects measured along relevant temporal and spatial scales and their cumulative effects measured in terms of the proportion of the habitat resource available to waterbirds in time and space that is impacted due to disturbance. Even then this is not a direct measure of the ecological relevance of the disturbance. Reduced numbers of birds at the site following periods of high disturbance could be an indicator of impact but more subtle energetic effects would still require detailed biological studies on a range of species.

Methods

In this report two approaches are taken to quantifying the disturbance effect of human activity the habitat resource available to populations of waterbirds, in time and space, at Castlemaine Harbour.

1. The coincidence, in time, in the use of the site by humans and waterbirds is estimated using semi-quantitative data of human activity associated with mussel production and the phenology of bird populations at the site.

2. The effect, on bird alert and flight responses, of different categories of individual disturbance events is modeled in time and space.

Temporal overlap of site use by humans and waterbirds

The routines described below were used to estimate an annual disturbance score for each species at the site. They are similar to the methods developed by Bell (2008). Spatial effects are ignored i.e any disturbance is presumed to affect all populations of all species. The temporal effect is also unbounded at resolutions less than a tidal period i.e. a disturbance event is presumed to have effect for the entire tidal period. The estimates of disturbance produced are therefore highly non-conservative.

Daily coincidence of species specific activity and disturbance activity

The overlap in habitat use by birds and mussel producers, each day can be quantified as follows

$$DailyDisturbanceScore = \sum_{period1}^{periodN} HabitatUse * DisturbanceUse$$

where a habitat use period is for instance feeding at low tide during the day or roosting at high tide during the night. The maximum daily coincidence (of mussel producers and bird use) score on the inter-tidal area is 2 and occurs when disturbance is present during both day and night low tide periods (Table 1).

Monthly Activity (related to mussel production) Scores

Monthly activity scores for activities related to mussel production are simply the proportion of days in a month when there is disturbance activity (Table 2). These scores are categorical with no weighting for level and frequency of activity or for spatial proximity to feeding or roosting habitats.

Relative phenologies of bird species at the site

Bird populations change seasonally at the site (Table 3). The patterns are species specific and, therefore, the potential for monthly mussel production activity to disturb birds also varies between species. The relative phenology scores weight the importance of any given month for a given species at the site relative to the month in which the peak count occurs on average during the period 1994-2007 (Table 4).

Monthly and annual disturbance impact score

The monthly disturbance impact score is the product of the daily coincidence score, the proportion of days in the month during which mussel related activity occurs and the relative phenology score for a given species for the month. It integrates the effects of daily overlap in habitat use by birds and activities related to mussel production, the number of days per month that overlap occurs and what proportion of the peak population of birds are present in the habitat during that month. The annual disturbance (Table 5) score is the sum of the monthly scores.

$$AnnualDisturbanceScore = \sum_{Jan}^{Dec} \left(DailyCoincidence * P_{days} * RP \right)$$

where P_{days} is the proportion of days in the month when disturbance occurs and RP is the relative phenology score for the month.

Results

The % of potential habitat use disturbed by mussel production activities

The coincidence scores provide an index of the proportion of the time which waterbirds use the inter-tidal habitat that can be disturbed by mussel production activity. The maximum potential daily score, measuring the overlap of bird habitat use and disturbance, is 2 (if both high tide and both low tide periods are disturbed throughout the area). As activities are restricted to daylight hours the effective daily score is 50% of the maximum. The maximum monthly score is 2 and occurs when the bird population is at its seasonal maximum (score =1), when mussel production activity occurs in all days (score = 1) of the month and during all tide periods during each day (score = 2). The maximum annual score for each activity is therefore 24. The annual score for each species therefore describes the percentage of the total habitat use time available to the birds that coincides with mussel production activity. This percentage is mitigated by the proposals in the fishery plan.

Annual % coincidence scores ranges from approximately 12% for Cormorant, Brent Geese, Mallard and Common Scoter to values of between 3-6% for waders (Table 5).

Table 1. Daily scores (present/absent) coincidence in use of the marine habitat in Castlemaine Harbour by birds and mussel producers

	Feeding & Roosting				Disturbance Activity				
	High tide day	Low tide day	High tide night	Low tide night	High tide day	Low tide day	High tide night	Low tide night	Daily Coincidence score
Species									
Wigeon	1	1	1	1	1	1	0	0	2
RT Diver	1	1	1	1	1	1	0	0	2
GN Diver	1	1	1	1	1	1	0	0	2
Cormorant	1	1	1	1	1	1	0	0	2
LBB Goose	1	1	1	1	1	1	0	0	2
Mallard	1	1	1	1	1	1	0	0	2
Pintail	1	1	1	1	1	1	0	0	2
Scaup	1	1	1	1	1	1	0	0	2
C Scoter	1	1	1	1	1	1	0	0	2
Oystercatcher	0	1	0	1	1	1	0	0	1
R Plover	0	1	0	1	1	1	0	0	1
Sanderling	0	1	0	1	1	1	0	0	1
BT Godwit	0	1	0	1	1	1	0	0	1
Redshank	0	1	0	1	1	1	0	0	1
Greenshank	0	1	0	1	1	1	0	0	1
Turnstone	0	1	0	1	1	1	0	0	1

Table 2. Proportion of days per month in which mussel production related activity occurs

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Boat traffic	0.32	0.18	0.16	0.17	0.48	0.5	0.48	0.48	0.5	0.48	0.33	0.32

Table 3. Long term monthly average phenology of waterbirds at Castlemaine Harbour (source: iWeBs)

Species	J	F	M	A	M	J	J	A	S	O	N	D	Max
Wigeon	2440	856	92	50					5500	10024	7000	4053	10024
RT Diver	12	8	1							6	13	22	22
GN Diver	25	16	26						1	5	17	20	26
Cormorant	81	150	86	25					211	118	194	86	211
LBB Goose	570	305	303						386	941	1062	793	1062
Mallard	424	240	179	20					419	545	773	738	773
Pintail	224	116	10						20	200	255	50	255
Scaup	203	202	117							2		210	210
C Scoter	500	203	411						119	346	450	332	500
Oystercatcher	1153	1713	766	100					656	1356	1214	1487	1713
R Plover	250	167	31						583	310	225	178	583
Sanderling	570	538	140						240	460	554	239	570
BT Godwit	227	375	70						73	836	279	349	836
Redshank	294	224	270	5					297	811	230	313	811
Greenshank	31	28	18						36	32	127	38	127
Turnstone	236	250	150						33	81	89	211	250

Table 4. Long term average monthly relative (to the month in which the peak count occurs as indicated by scores of 1.0) phenology scores for waterbird species in Castlemaine Harbour

Species	J	F	M	A	M	J	J	A	S	O	N	D
Wigeon	0.24	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.55	**1.00**	0.70	0.40
RT Diver	0.55	0.36	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.59	**1.00**
GN Diver	0.96	0.62	**1.00**	0.00	0.00	0.00	0.00	0.00	0.04	0.19	0.65	0.77
Cormorant	0.38	0.71	0.41	0.12	0.00	0.00	0.00	0.00	**1.00**	0.56	0.92	0.41
LBB Goose	0.54	0.29	0.29	0.00	0.00	0.00	0.00	0.00	0.36	0.89	**1.00**	0.75
Mallard	0.55	0.31	0.23	0.03	0.00	0.00	0.00	0.00	0.54	0.71	**1.00**	0.95
Pintail	0.88	0.45	0.04	0.00	0.00	0.00	0.00	0.00	0.08	0.78	**1.00**	0.20
Scaup	0.97	0.96	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	**1.00**
C Scoter	**1.00**	0.41	0.82	0.00	0.00	0.00	0.00	0.00	0.24	0.69	0.90	0.66
Oystercatcher	0.67	**1.00**	0.45	0.06	0.00	0.00	0.00	0.00	0.38	0.79	0.71	0.87
R Plover	0.43	0.29	0.05	0.00	0.00	0.00	0.00	0.00	**1.00**	0.53	0.39	0.31
Sanderling	**1.00**	0.94	0.25	0.00	0.00	0.00	0.00	0.00	0.42	0.81	0.97	0.42
BT Godwit	0.27	0.45	0.08	0.00	0.00	0.00	0.00	0.00	0.09	**1.00**	0.33	0.42
Redshank	0.36	0.28	0.33	0.01	0.00	0.00	0.00	0.00	0.37	**1.00**	0.28	0.39
Greenshank	0.24	0.22	0.14	0.00	0.00	0.00	0.00	0.00	0.28	0.25	**1.00**	0.30
Turnstone	0.94	**1.00**	0.60	0.00	0.00	0.00	0.00	0.00	0.13	0.32	0.36	0.84

Table 5. Annual disturbance scores and % overlap between the occurrence of disturbance activity due to mussel production activity and the habitat use pattern for each bird species. Spatial effects are ignored and assumed to act throughout the site (but see text above for overall evaluation of spatial effects)

Species	Annual impact	%
Wigeon	2.4	10.15
RT Diver	1.8	7.50
GN Diver	2.3	9.66
Cormorant	3.1	12.87
LBB Goose	2.9	12.13
Mallard	3.1	12.73
Pintail	2.4	9.89
Scaup	1.8	7.51
C Scoter	3.0	12.46
Oystercatcher	1.6	6.53
R Plover	1.2	4.93
Sanderling	1.6	6.63
BT Godwit	1.0	3.98
Redshank	1.1	4.61
Greenshank	0.8	3.48
Turnstone	1.2	4.97
	Average	**8.13**

Modelling the disturbance effect, in space and time, of individual disturbance events

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Summary

During the transect counts in February and March 2010 (see above), counters recorded all human activity, and any impacts caused by these activities, and any other factors that caused disturbance to the birds in the transects being counted. The area covered by this disturbance recording included the full extent of the mussel nursery area (apart from small areas that were not covered because of the failure of one counter to submit disturbance information) and the duration covered the entire low tide period during which the mussel nursery area was exposed. We used the observed alert and flight response distances and recovery times to calculate the amount of the habitat resource affected by all mussel-related disturbance activities.

Mussel-related disturbance activities occurred on four out of the five survey days and affected a mean of 6.8% of the available habitat resource, using the alert response distance, and 2.4% using the flight response distance.

These potential disturbance effects are overestimates of the actual disturbance impacts for a number of reasons. We consider that the actual mean disturbance impact per low tide period would be reduced by at least 50-75%, and probably lower than even the lower end of that range.

Methods

Disturbance recording was carried out during the transect counts on 3 February, 14 February, 15 February, 4 March and 5 March 2010. The disturbance recording took place throughout the count period, including any gaps between counts, and was not limited to events that took place during individual counts.

Each counter was instructed to record all human activity within 200 m of the transects that they were counting and any other factors (birds of prey, or human activity more than 200 m from the transects) that caused disturbance to the birds in the transects being counted. However, one counter did not submit any disturbance information

Counters recorded disturbance activities and impacts directly onto standardised disturbance maps and forms in the field. The recording of disturbance activities and impacts followed a logical sequence:

- The spatial extent of the relevant activities was recorded onto the disturbance map and each activity assigned a unique event reference.
- Details of the timing and nature of the activity was recorded on the disturbance activity form and cross-referenced to the disturbance map by the event reference.
- If the activity caused impacts to birds, then details of the impact was recorded on the disturbance impact form and cross-referenced to the disturbance map and disturbance activity form by the event reference. In addition, the time of the impact was recorded, allowing cross-reference to the relevant count, if applicable.

Because the recording of disturbance activities and impacts extended for up to 200 m outside the transects being counted, there was some duplication in the recording of disturbance activities and impacts. During data processing, we screened the data to identify duplication. Where duplication occurred, the data from the counter that was closer to the event being recorded was used. We did not identify any major discrepancies in the recording of disturbance activities and impacts where duplication occurred.

During data processing, we classified activities as mussel-related if either the observer had indicated this in the information that they had recorded, or if the description of the activity indicated that it was mussel-related. The latter involved cases where people were recorded arriving by boat and walking around a section of the mussel nursery area without engaging in any distinct activity such as winkle picking. We considered this behaviour to be seed mussel inspections.

As discussed above, one counter did not record any disturbance information. The disturbance information recorded by the counters covering the adjacent transect groups on each survey day indicates that disturbance activities occurred in the transect groups covered by this counter on at least some of the count days. However, because of the overlap in areas covered by the various counters, the actual area not covered by any of the other four counters on any of the days was small. In some cases we have interpolated disturbance information from the counters covering the adjacent transect groups to fill in gaps due to the counter who did not record disturbance information.

In some cases counters recorded alert or flight response distances as a range (e.g., 50-100 m) or as a minimum (e.g., 100+ m). In such cases, for calculation of means we used the midpoint of the range or the minimum value.

Results

Disturbance activities and impacts

Between one and four disturbance events were recorded on the five transect count days (Table.6). The spatial distribution and extent of the disturbance activities on each count day are shown in Figure.1-Figure.5.

Table.6 – Potential disturbance events recorded during transect counts.

Date	Event	Activity	Humans	Dogs	Duration	Impact
03-Feb	1	Winkle picking	3		02:59	No
03-Feb	2	Working on lower shore cages (mussel-related)	3		03:30	No
15-Feb	1	Winkle picking	1	1	03:29	Yes
16-Feb	1	Winkle picking	4	1	03:20	Yes
16-Feb	2	Seaweed collection (mussel-related)	1	1	02:35	Yes
16-Feb	3	Forking mussels into boat	1		> 00:15	Yes
16-Feb	4	Working on lower shore cages (mussel-related)	4		04:00	?
04-Mar	1	Winkle picking	1		03:00	Yes
04-Mar	2	Working on lower shore cages (mussel-related)	2		02:39	Yes
04-Mar	3	Mussel inspection	1		00:15	Yes
05-Mar	1	Winkle picking	1	1	02:43	Yes
05-Mar	2	Hanging nets (mussel-related)	2		02:36	No
05-Mar	3	Walking along lower shore	1	1	?	Yes

Date	Event	Activity	Humans	Dogs	Duration	Impact
05-Mar	4	Mussel inspection	1		00:39	Yes

A total of 14 incidences of disturbance causing detectable impacts to birds were recorded, out of which a flight response was recorded on 13 occasions (Table.7). Of the 14 disturbance incidences, 13 involved Oystercatchers, nine involved Curlew and seven involved Redshank, with single incidences affecting Light-bellied Brent, Dunlin, Bar-tailed Godwit, Herring Gull, Great Black-backed Gull and unidentified gulls.

Table.7 – Disturbance incidences recorded

	Alert response		Flight response	
Date	Recorded	Not recorded	Flew	Did not fly
03-Feb	0	0	0	0
15-Feb	1	0	1	0
16-Feb	4	3	6	1
04-Mar	2	0	2	0
05-Mar	3	1	4	0

The frequency distribution of distances at which birds showed alert and flight responses are shown in Figure.6 and Figure.7.

The mean recorded distance at which birds showed an alert response was 125 m (s.d. = 48.6, n = 10).

There were four incidents when the alert response was not recorded. On these four occasions, birds flew at a distance of 200-300 m in response to a dog that was running up and down the intertidal area and it is unlikely that the birds would have had time to show an alert response before they flew due to the rapid movement of the disturbance source. Therefore, we have calculated an adjusted mean alert response distance by using a value of 250 m as the alert response for these incidents. This gives a mean alert distance of 161 m (s.d. 71, n = 14).

The mean recorded distance at which birds showed a flight response was 79 m (s.d. = 68, n = 14). There was one incident when birds did not fly. On this occasion, the birds showed an alert response at a distance of 50-60 m. Therefore, we have calculated an adjusted mean flight response distance by using a value of 55 m as the flight response distance for this incident. This gives a mean flight distance of 78 m (s.d. 66, n = 15)[1].

38 of the 469 transect counts were considered by the counters to have been affected by disturbance (Table.8). On 18 of the 31 of these counts where it was recorded the distance from the last disturbance event was 100 m or less while on three of these counts the distance was 200 m or more.

On 27 of the 33 counts affected by disturbance where it was recorded, the time since the last disturbance event was 1 minute or less, while the maximum time since the last disturbance event after which a count was still considered to be affected by disturbance was 45 minutes.

[1] There was one incident when the species affected by the disturbance impact showed flight responses at different distances (CU at 100 m and GB at 50 m). This accounts for the difference in sample sizes between the adjusted alert response and flight response data.

Table.8 – Transect counts affected by disturbance

Distance from transect of last disturbance event	Number of incidences	Time since last disturbance event[1]
0 m	15	0 min (13), 15 min, NR
40 m	1	0 min
50 m	3	0 min (3)
50-150 m	2	0 min, 10 min
100 m	2	0 min, 20 min
150 m	4	0 min (3), 25 min
170 m	1	43 min
200 m	2	0 min (2)
250 m	1	0 min
NR	7	1 min (2), 45 min, NR (4)

NR = not recorded

[1] where multiple incidences of the same time value were recorded the number of incidents is given in parentheses

The recovery period recorded by counters following a disturbance event within 100 m of a transect varied from 7-45 minutes (Table.9). The recovery period recorded by the counters was constrained by the timing of the transect counts. Therefore, the actual recovery period will usually have been less than the recorded value.

Table.9 – Transect counts not affected by disturbance and with non-zero waterbird counts where the distance from the transect of the last disturbance event was 100 m or less and the time since the last disturbance event was 45 minutes or less.

Distance from transect of last disturbance event	Number of incidences	Time since last disturbance event
0 m	3	15 min, 20 min, 30 min
50 m	1	35 min
75 m	1	45 min
100 m	4	7 min, 15 min, 35 min, 45 min

On 4 and 5 March, a dredger was working in the channel close to the tideline below the nursery area. This dredger did not cause any detectable impacts to birds within the nursery area.

Potential disturbance impact from mussel-related activities

We have attempted to quantify the potential disturbance impact from mussel-related activities by applying buffers to the mapped activities representing the mean alert and flight response distances (161 and 78 m, respectively) and multiplying the area affected by the duration of the activity plus a recovery time. Therefore, we have quantified the potential disturbance impact as a value in hectare minutes (ha min) representing the habitat resource that was potentially affected.

To quantify the relative disturbance effect, we divided the potential disturbance impact value by the total habitat resource available. We defined the latter as the total area surveyed (the area enclosed by a 200 m buffer of all the transects minus the area not covered by disturbance recording) multiplied by the total duration of the period during which the mussel nursery area is exposed. On each low tide, the mussel nursery area is fully exposed for around two hours. There are periods of approximately one hour either side of this when the tideline is moving through the mussel nursery area. Therefore, we used a value of 180 minutes for the total duration of the period during which the mussel nursery area is exposed.

Using the mean of the times in Table.8 or Table.9 for the recovery time would not necessarily be appropriate as these values are constrained by the timing of the transect counts and do not necessarily reflect the actual distribution of recovery times. However, Table.8 shows that in 25 of the 27 counts affected by disturbance where it was recorded the time since the last disturbance event was 25 minutes or less, while the mean of the recorded recovery periods in Table.9 is 27 minutes (s.d. 14, n = 9). Therefore, a value of 30 minutes seems to be reasonable as a typical recovery period duration.

Because the humans and dogs that were responsible for disturbance activities moved around during the duration of the activity, we applied buffers to each location that they visited in sequence. We calculated the duration of potential impact in areas of overlap between buffers by taking the earliest start time and the latest end time. If the start time of the later buffer was more than 30 minutes after the end time of the earlier buffer, we retained separate buffers in the area of overlap.

Where the end time plus 30 minutes exceeded the end time of the observation period, we used the end time of the observation period to calculate the duration of potential impact. On each day, the observation period ended when the tide had covered the mussel nursery area, so disturbance activities could not have had any impact on waterbirds using intertidal habitat after this time.

Mussel-related disturbance activities occurred on four out of the five survey days. The potential disturbance effect from these activities affected between 7-11% of the habitat resource (mean 6.8%, s.d. 4.1), using the alert response distance, and 2-4% (mean 2.4, s.d. 1.5) using the flight response distance (Table Table.10).

Table.10 – Potential disturbance impact of mussel-related activities on the available habitat resource, where the habitat resource is measured as the product of the area of intertidal habitat available and the duration of its exposure

Date	Area covered by disturbance recording	Habitat resource potentially affected:	
		alert response	flight response
03-Feb	212 ha	2533 ha min (7%)	779 ha min (2%)
15-Feb	184 ha	0	0
16-Feb	187 ha	3566 ha min (11%)	1098 ha min (3%)
04-Mar	209 ha	2487 ha min (7%)	992 ha min (3%)
05-Mar	203 ha	3272 ha min (9%)	1384 ha min (4%)

The potential disturbance effects in Table.10 will be overestimates of the actual disturbance impacts for a number of reasons:

1. The buffer areas used to calculate these effects will include some areas that are covered by the tide for at least part of the duration of the potential disturbance effect. This would mainly involve the periods at the start/finish of the disturbance activity when the tideline is within the alert/flight response distance of the activity. This would typically amount to around 25% of the duration of activities that lasted the duration of the low tide period. However, this factor would

not be so relevant to seed mussel inspections, as these are of short duration and typically occur during the middle of the low tide period.

2. Waterbirds mainly use the mussel nursery area while the tideline is moving through it. Very few waterbirds use the mussel nursery area when the tideline is below it. Therefore, much of the duration of the potential disturbance effects (probably at least 50%) will have covered periods during which waterbirds are unlikely to have used the areas affected even if there had not been any disturbance activities.

3. Disturbance activities were recorded on days with spring low tides and with good weather conditions. Inspections of the seed mussel typically take place during spring low tides (Marine Institute Fisheries Science Services, 2009) so less activity is likely to take place during neap low tides. It is also likely that less activity will take place on days with poor weather conditions, particularly when strong northerly winds prevent boat access from Cromane.

4. During low tide periods that occur at night there will presumably not be any disturbance impacts. Nocturnal feeding is known to be important for both Curlew and Redshank (Cramp & Simmons, 2004) and Curlew habitually feed at night on intertidal habitat in Cork Harbour (T. Gittings, pers. obs.).

For the above reasons, we consider it likely that the actual mean disturbance impact per low tide period would be much lower than the potential disturbance effect values in Table.10. The factors listed in 1 and 2 above, would probably reduce the disturbance impact by around 50-75% and the factors listed in 3 and 4 above would further reduce the disturbance impact, depending on weather conditions and species behaviour.

There is possibility that, by chance, our count days coincided with days of unusually low activity. However, Atkins personnel were on site on the mussel nursery area for the full duration of low tide periods on another 11 days during January-April 2010 installing stakes to mark transect boundaries and carrying out mussel surveys and we consider that the overall level of activity during the count days was not atypical.

Conclusions

Mussel-related disturbance activities occurred on four out of the five survey days and affected a mean of 6.8% of the habitat resource, using the alert response distance, and 2.4% using the flight response distance.

These potential disturbance effects are overestimates of the actual disturbance impacts for a number of reasons. We consider that the actual mean disturbance impact per low tide period would be reduced by at least 50-75%, and probably lower than even the lower end of that range.

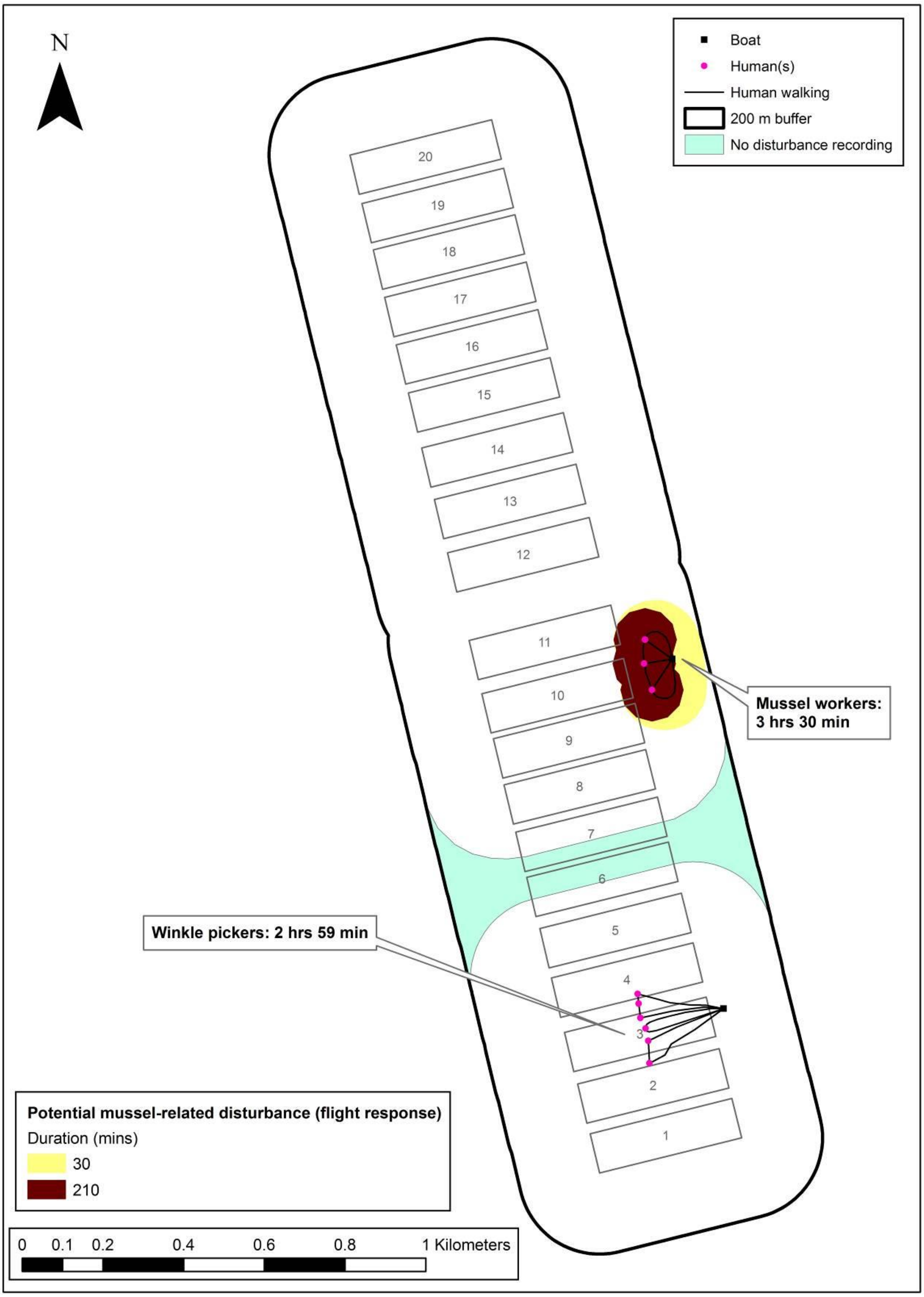

Figure.1 – Disturbance activities recorded on February 3 2010.

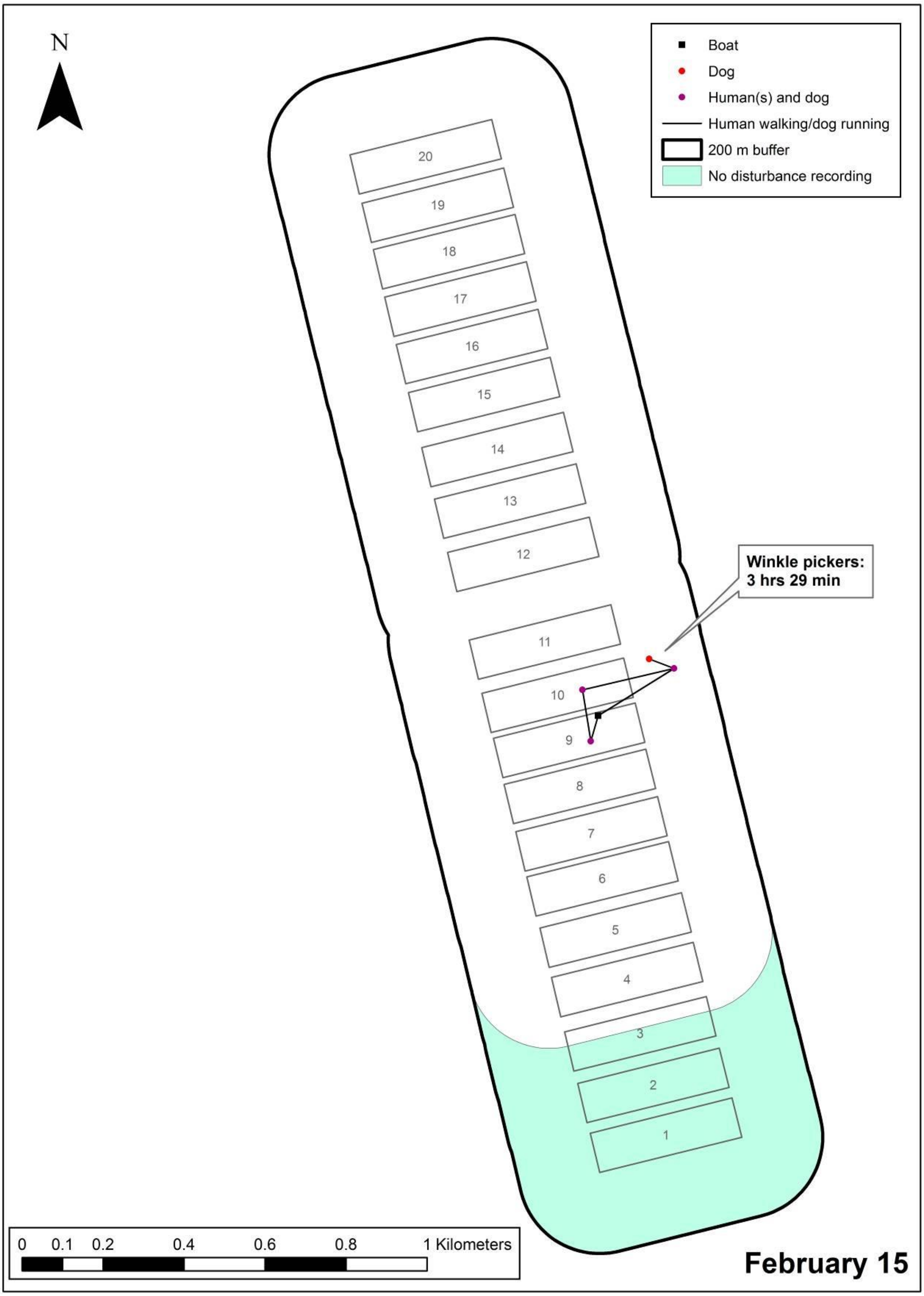

Figure.2 – Disturbance activities recorded on February 15 2010.

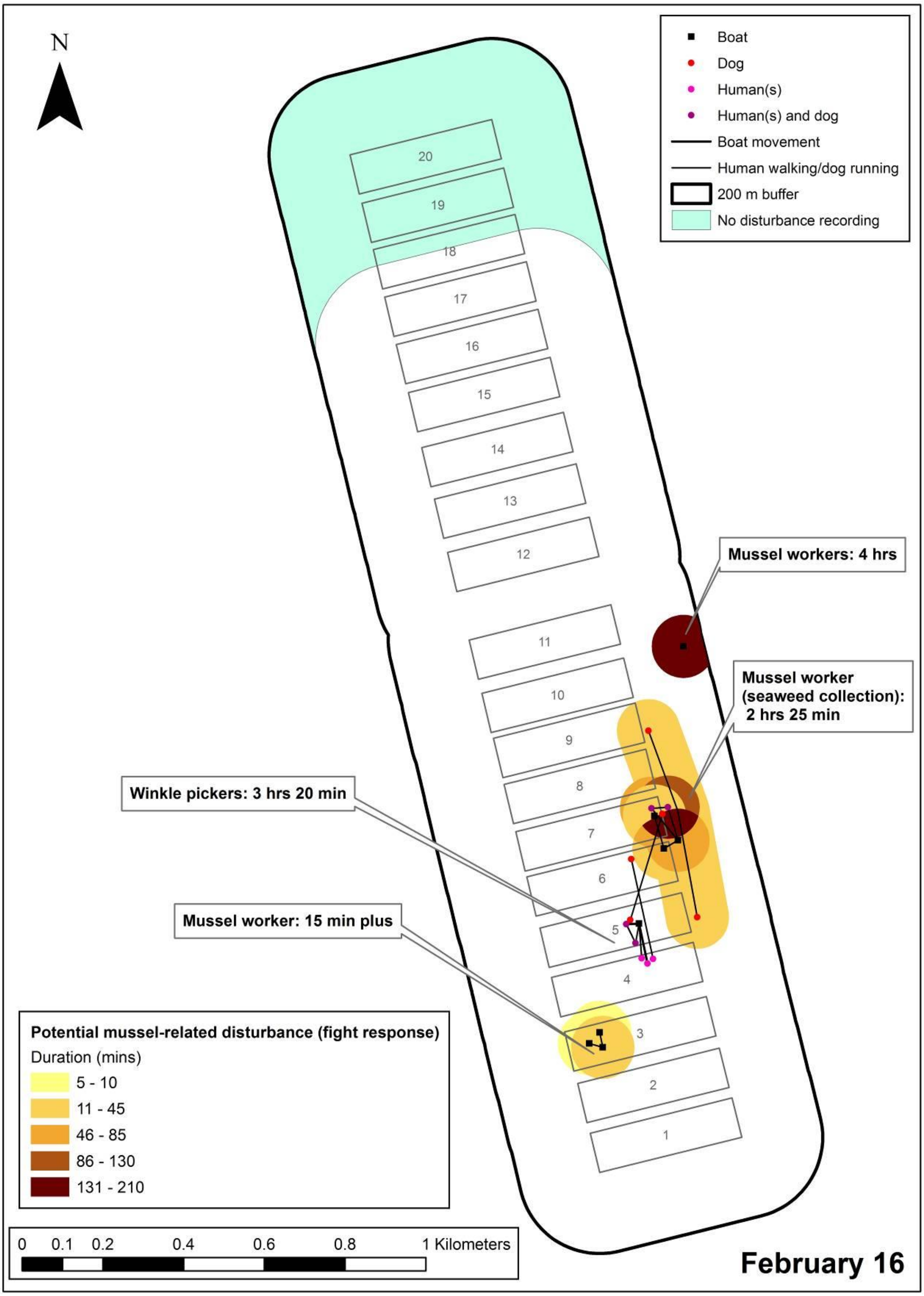

Figure.3 – Disturbance activities recorded on February 16 2010.

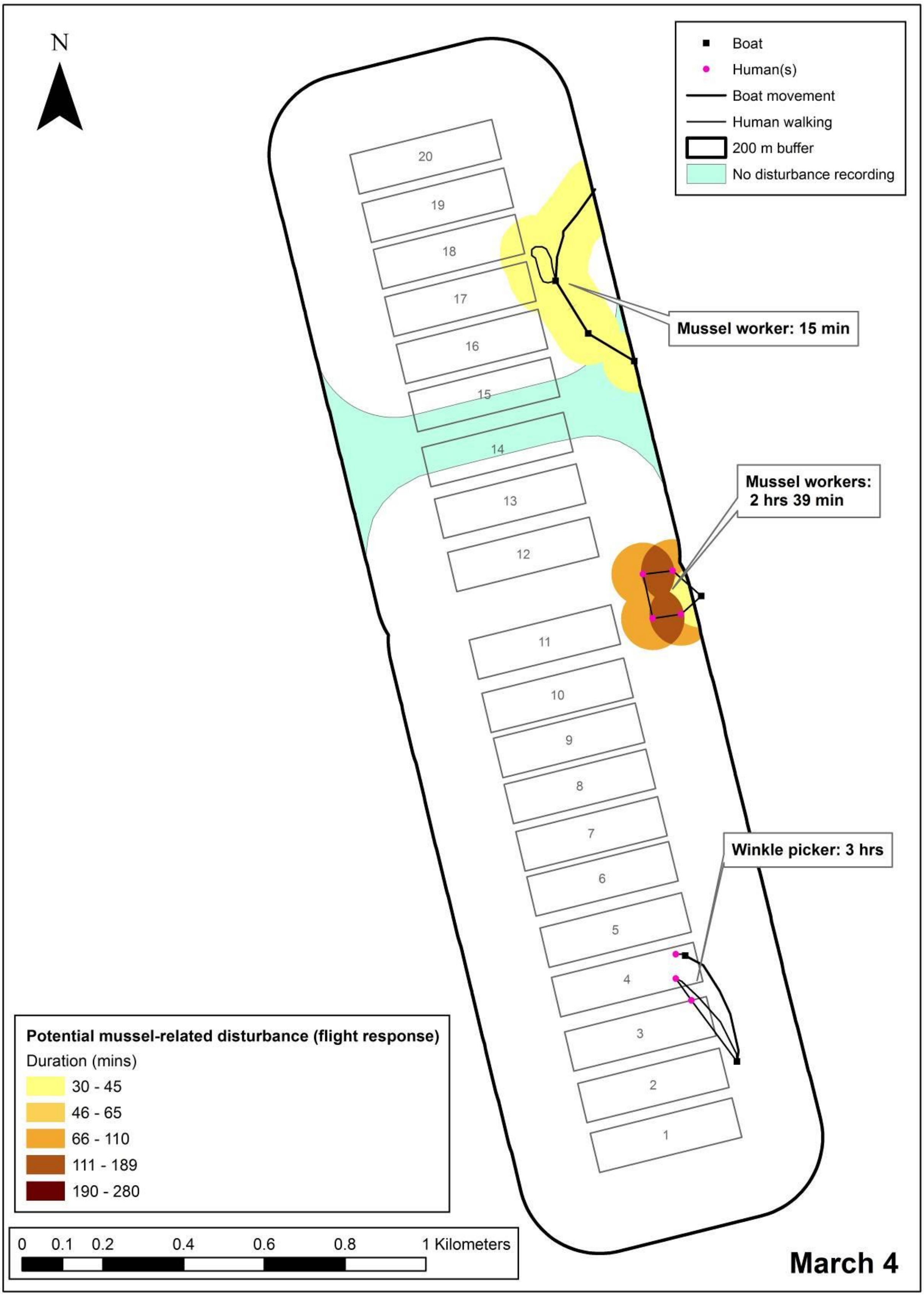

Figure.4 – Disturbance activities recorded on March 4 2010.

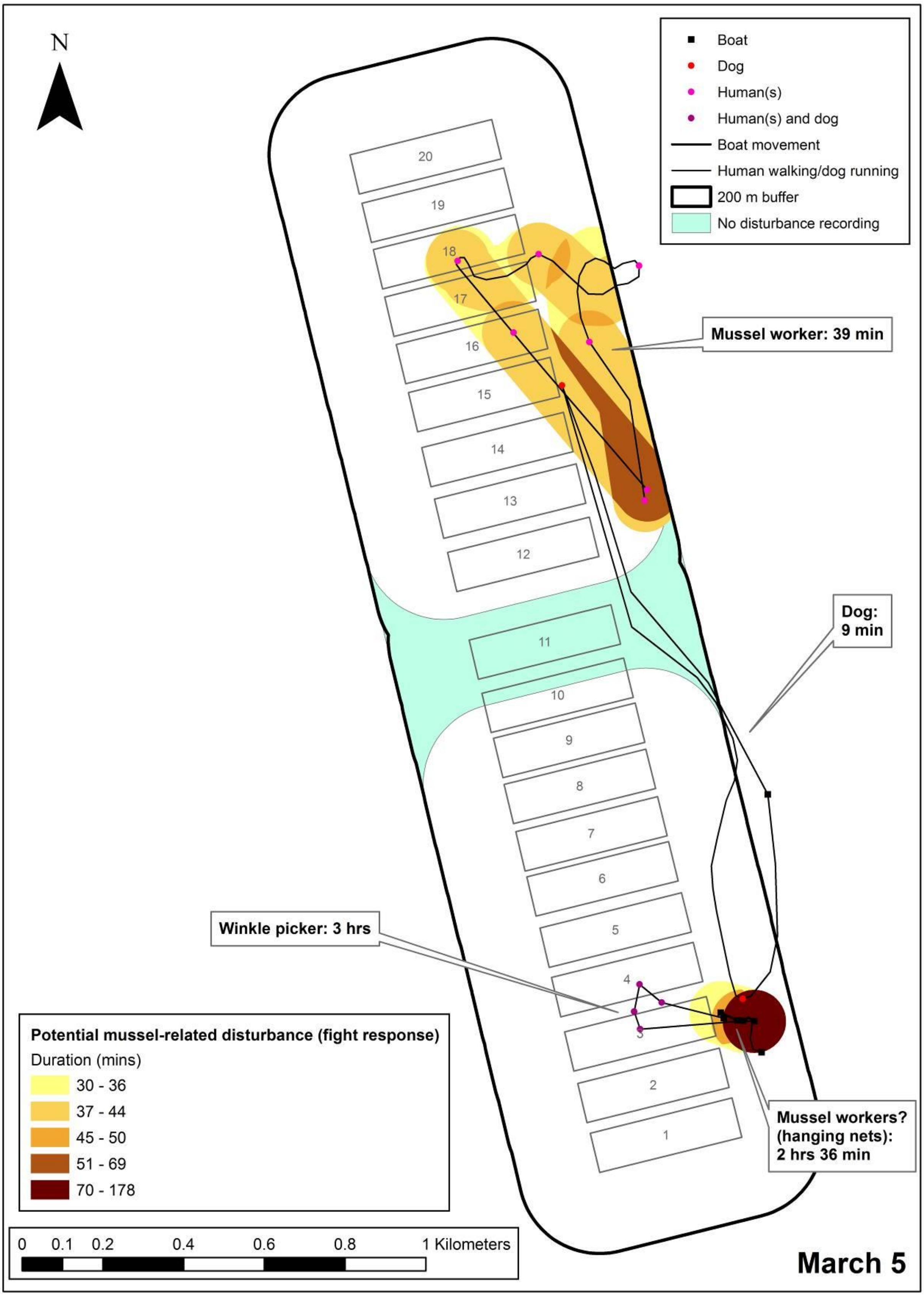

Figure.5 – Disturbance activities recorded on March 5 2010.

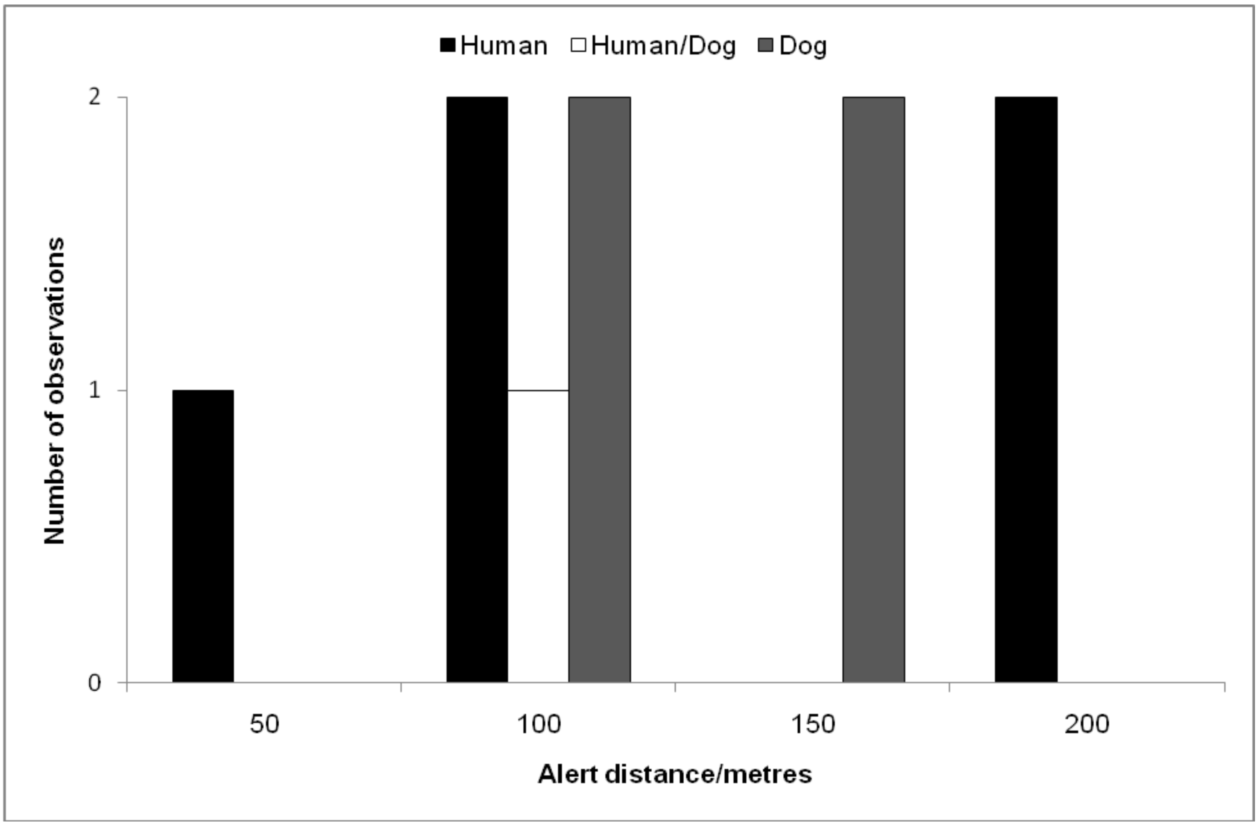

Figure.6 – Alert distances recorded during observed disturbance incidents.

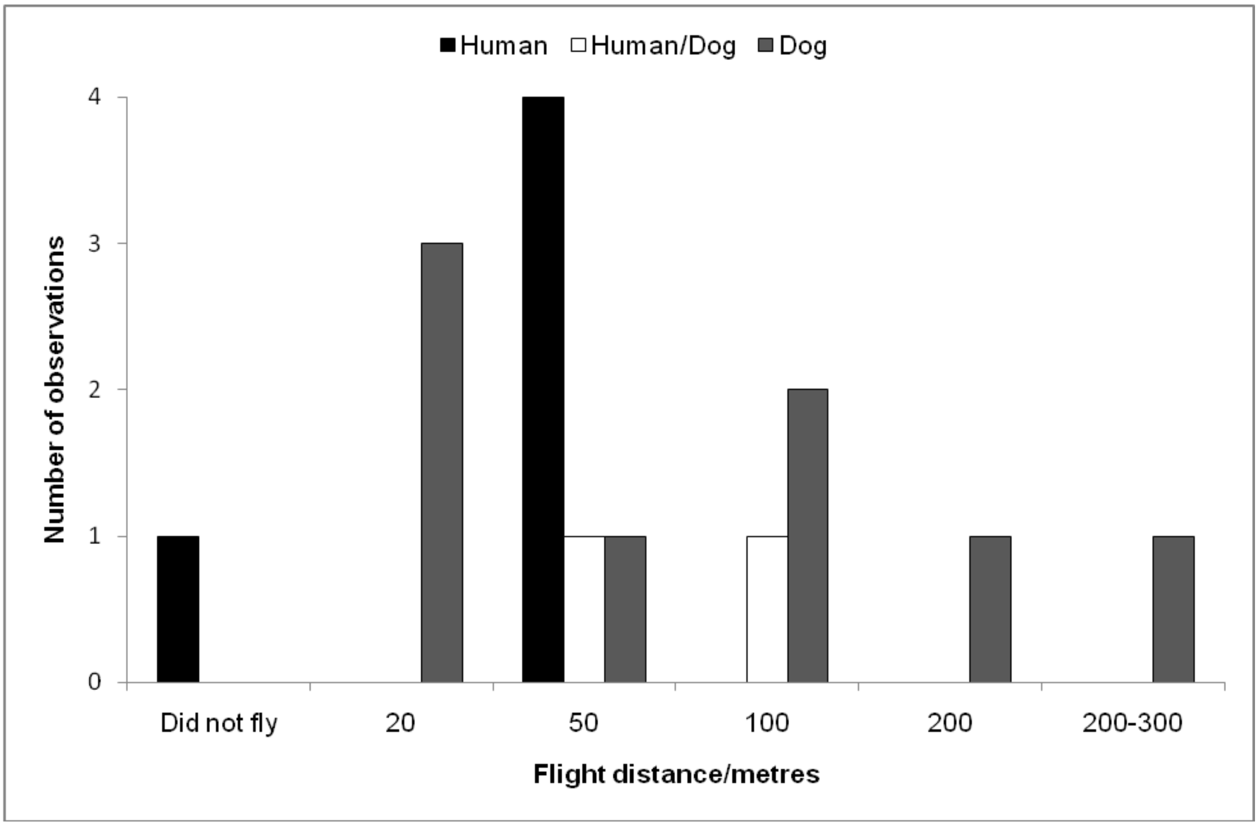

Figure.7 – Flight distances recorded during observed disturbance incidents